Photogrammetry

Konrad Schindler, ETH Zürich
Wolfgang Förstner, Bonn University

Related Concepts

– Image Understanding
– Multi-view Reconstruction
– Remote Sensing
– Structure-from-Motion
– Topographic Mapping

Definition

Photogrammetry is the science and technology of obtaining information about the physical environment from images, with a focus on applications in surveying, mapping and high-precision metrology. The aim of photogrammetry is to provide automated or semi-automated procedures for these engineering tasks, with emphasis on a specified accuracy, reliability, and completeness of the information.

Background

Photogrammetry is a long-established engineering discipline, which dates back to the middle of the nineteenth century, shortly after the invention of the photographic process. It has its roots in surveying, predominantly for aerial mapping of the earth's surface, although terrestrial "close-range" photogrammetry has always been an integral part of the discipline. Traditionally photogrammetry has emphasised 3D *geometric* modeling of the environment, since in an interactive setting this implicitly encompassed the semantic interpretation of the image content. The use of geospatial imagery with the primary purpose to infer semantic object properties from radiometric intensities is often referred to as "remote sensing". Today these two fields overlap in terms both of methodology and of applications.

Methods

The goal of photogrammetry is to extract geometric and semantic information from imagery.

In terms of *geometric* processing methods, the photogrammetric measurement process is essentially an application of structure-from-motion theory [8], mostly (but not exclusively) with calibrated camera intrinsics. In fact a large part of the theory of camera calibration and camera orientation was first developed and applied in photogrammetry, including camera orientation from 2D-to-3D correspondences [7,1], relative camera orientation from 2D-to-2D correspondences [4], and bundle adjustment [3].

The methods for *semantic* interpretation comprise the entire armamentarium of image understanding, from early rule-based systems [19] through model-based object recognition [24] to statistical learning with modern Bayesian techniques [21]. For an overview on classical techniques, see [16].

Deep learning is used for geometric and interpretation tasks with remote sensing data for land cover classification [17,14,26], with aerial images [25] for building extraction or with laser data [22,12,2] for interpreting terrestrial environments.

Due to the complexity of the task, only semi-automatic methods have so far found their way into commercial software and operational production pipelines.

Relation to Computer Vision

Since the advent of digital images in the 1970s, a main goal has been to automate the photogrammetric process, and photogrammetrists have developed or adopted pattern recognition methods for tasks such as interest point extraction [20], feature matching and dense stereo reconstruction [10,9], semantic segmentation [15] and object category detection [6]. Thus, the science of photogrammetry is increasingly converging with computer vision and image understanding. Still photogrammetry, being a practical engineering discipline, tends to put greater emphasis on a defined (usually high) accuracy, reliability and completeness than on total automation.

Recent Developments in Sensor Technology

Since the 1990s, range images captured directly with airborne and terrestrial laser scanners have gained popularity with both practitioners and researchers in geo-information and have become a second main data source of photogrammetry [23].

Hand in hand with that development, it has become a standard routine to determine approximate or even final sensor orientations directly, rather than indirectly from observed points. The practice of observing the position and attitude of the camera during flight missions directly with a highly accurate GNSS (global navigation satellite system) receiver and IMU (inertial measurement unit) is known as *direct georeferencing*.

With the advent of high-resolution satellite sensors, spaceborne images from both optical and microwave sensors nowadays also serve as input data for the photogrammetric process. Mobile mapping systems mounted on vehicles have led to a growing interest in large-scale photogrammetric mapping from the ground.

Classical photogrammetric textbooks are [13], [18], and most recently [5].

Application

The most important application field of photogrammetry is topographic mapping of the earth's surface at different scales. The overwhelming majority of all existing maps have been created through photogrammetric processing of airborne or spaceborne imagery. However, photogrammetry is also prominent for small-scale mapping down to single villages, mines *etc*. A related endeavour has been the mapping of other planets in the solar system from images taken by spacecraft.

Non-topographic applications for a long time occupied only a small fraction of the market. They used to be subsumed under the term "close-range photogrammetry", the main application fields being industrial metrology (e.g., aircraft, ships, vehicle parts), construction, cultural heritage documentation, forensics, and the medical domain.

Although mapping remains the dominant application area, the boundary between photogrammetry and 3D computer vision is dissolving more and more. Today tasks like visual driver assistance and robot navigation, motion capture, virtual and augmented reality, object tracking, *etc*. are by many also considered applications of photogrammetry.

Technology transfer between academia and industry has always been well established in photogrammetry, via the International Society for Photogrammetry and Remote Sensing (ISPRS, `http://www.isprs.org`) and the long-running biennial Photogrammetric Week (`http://www.ifp.uni-stuttgart.de/publications/phowo.html`).

Recommended Readings

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